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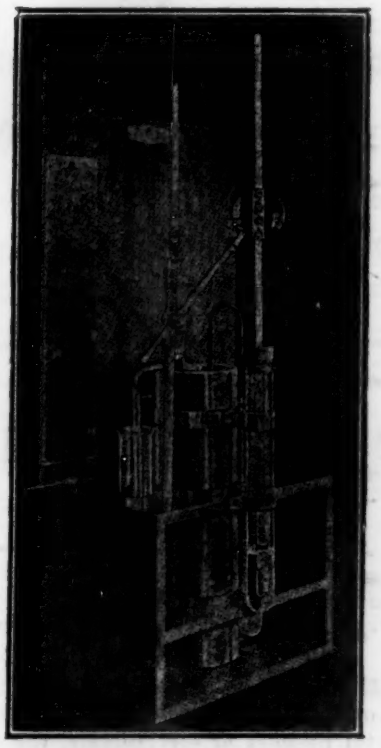

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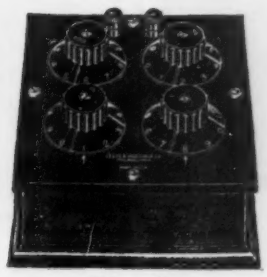

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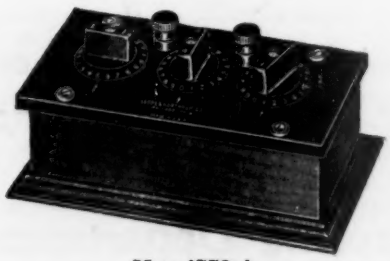

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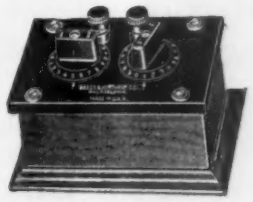

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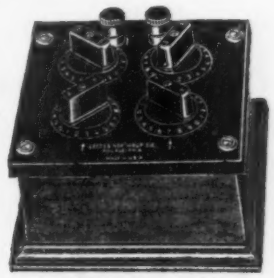

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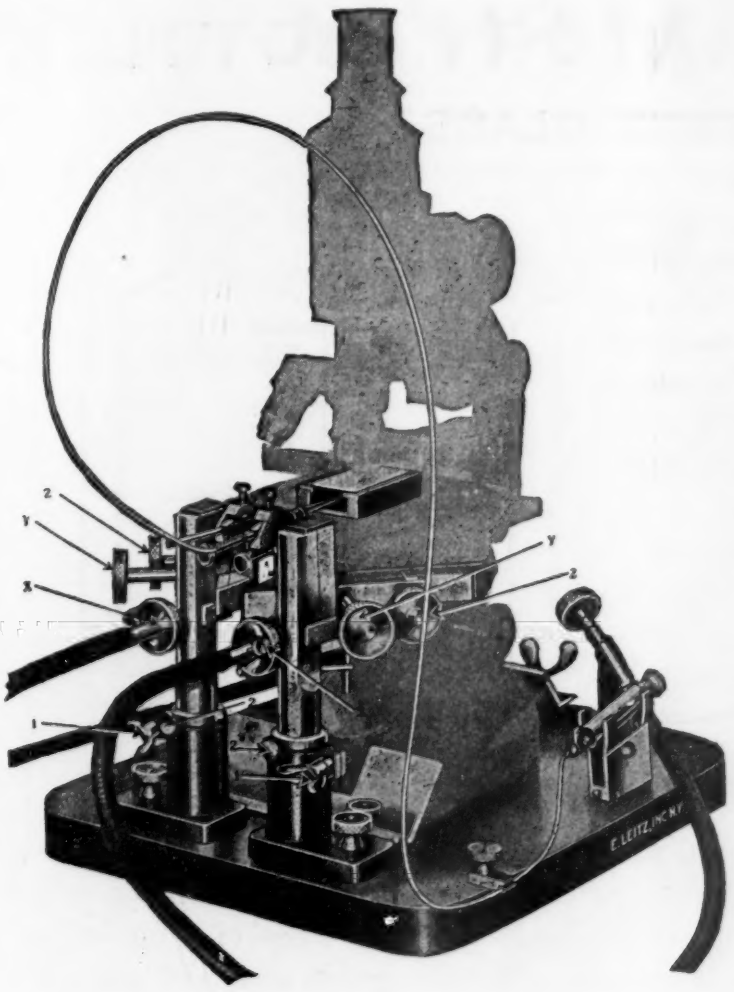

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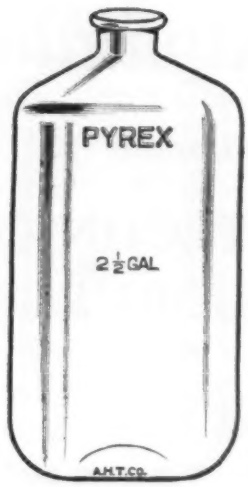

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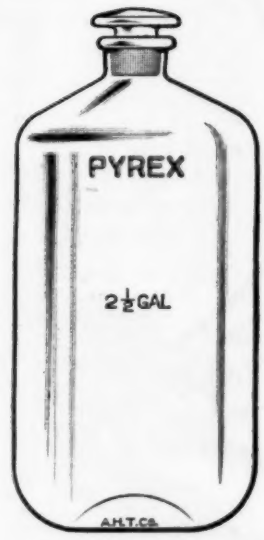

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THE ART AND SCIENCE OF MEDICINE[1]

THIS twentieth anniversary meeting of the American Society for Clinical Investigation marks the active inauguration of a policy which has for its purpose the perpetuation of the youthfulness of the organization. The members who to-day retire to the emeritus list are those who formed the society and on whose shoulders for many years fell the burden of directing its course. During this score of years in this country has occurred practically the entire growth of medical clinics as we understand them to-day. The physical organization and intellectual direction of most of these clinics has fallen to the lot of our early members. As a result of this pioneer work the younger members of this society have at their disposal facilities for following careers as clinical investigators scarcely equalled anywhere in the world.

But points of view are probably more important than mere places for work. It is sometimes well to stop and survey our territory, our methods and our attitude. An anniversary event, such as we are to-day celebrating, offers an opportunity for such a survey.

Not unfamiliar to you are the terms "science of medicine" and "art of medicine." Usually they are expressed in a manner which implies the existence of two mutually exclusive fields or manners of endeavor. It is true that custom gives meaning to words or phrases; but this is no excuse for allowing these phrases to fix unalterably our attitude towards the subjects which they symbolize.

In the expression "art and science of medicine" at least three separate ideas are included: medicine, art and science; hence it becomes desirable to attempt to define these terms. Medicine is that department of biology which considers disease in all its aspects. This assumes that disease is a departure from normal living, *i.e.*, from physiological processes. Correctly speaking, it would exclude from study the manifestations of aging, for these in a strict sense must be considered as physiological, *i.e.*, normal to life. But such definitions must be generally inclusive rather than specifically exclusive. In a field as broad as medicine we can define the aims, but the boundaries and ramifications must not be limited.

[1] Presidential address before the American Society for Clinical Investigation, Washington, D. C., April 30, 1928. From the hospital of the Rockefeller Institute for Medical Research, New York City.

In the development of language the ideas represented by the words art and science have been closely related. Art implies arrangement, a creation of special conditions or relationships from available material; it is not concerned with the origin of the material, but merely uses that which seems best suited for a definite purpose. Science, on the other hand, consists in knowledge of the phenomena of nature; its function is to determine the materials and relationships in any given condition. This, of necessity, implies the discovery of new ones, if all possible features and combinations are not already known. The relationship of the two ideas has been paraphrased thus: "Art consists in doing, science consists in knowing." In other words, when one tries to do something in order to know he must use the technique and methods of art. When, on the other hand, he tries to know something in order to do, he must either take the knowledge science has furnished, or go to nature and apply the methods of science to furnish him with new knowledge. Thus he assumes the alternate rôle of scientist or artist, according to the immediate aim of his requirements. As the sum of our knowledge is still relatively small, and as there is an ever-increasing addition of new discoveries, obviously there occurs an ever-constant change in the relationship of the known and knowable. Hence the scope of both art and science is continually altering; art has a never-ending task in arranging new combinations of materials which are constantly increased by science.

In his effort to help himself when sick or injured primitive man doubtless made and correlated observations which constituted a crude science of medicine; but the admixture of religious superstition constantly confused the picture. Only with the Greeks did the various relationships of medicine become well formulated. The main characteristics of Hippocratic medicine included: (1) Its social aspects, the relationship of physicians to one another and to the patients as exemplified in the Hippocratic oath; (2) its scientific aspects, the necessity for observation of the phenomena of disease, and the recognition of laws governing disease. This doubtless resulted from the comparison of the results of observation; (3) its aspects as an art. The possibility of arranging conditions to alter effects was recognized in a system of therapeutics.

While the study of human anatomy flourished, its chief effect seemed to emerge in the plastic arts rather than as an aid to the physician. Because the study of disturbed function could not be readily correlated with that of abnormal form in a system of pathology, the school of Empiricism developed in Alexandria in the same environment that fostered the most distinguished anatomists. As empiricism has always such an important place in medicine it may be useful to note the method developed in that school. It rested upon the tripod of (1) observation, (2) history (record of observation) and (3) judgment by analogy. One can not but recognize the importance of empiricism in the development of knowledge in all branches of science. Particularly in utilizing the results of comparative physiology and pathology is it necessary to apply argument by analogy. The chief weakness of the system for centuries, however, rested in the limitations imposed by the formation of judgment *exclusively* by analogy.

Furthermore, not the least of the dangers of empiricism is the presence of scholasticism, which is undue worship of authority and the acceptance of judgment of others unsubstantiated by experiment. This was for centuries the great handicap, which even to-day is imposed by a too rigorous schedule of formal instruction in our schools. True, Galen tried to combine the study of function and form in physiology and anatomy. But his misinterpretations of the functions of many anatomical structures were perpetuated by the Scholastics until comparatively recent times.

But with the Renaissance a new attitude developed. In the person of Francis Bacon the feeling against the old scholastic doctrines which blindly followed authority became so strong that an entirely new method of learning was evolved. To remove the influence of preformed judgments he advised the attaining of knowledge by observation of as many facts or phenomena as possible, and then in any given case the elimination of the unessential by means of tables. But elimination involves the art of judgment; and time has shown that scientific judgment is best controlled by experiment. Indeed, during the period when Bacon was developing his inductive method, many scientists were applying the experimental method and establishing facts that have stood the test of time. Probably of greatest import to us as physicians was the discovery of the circulation of the blood by Bacon's contemporary, Harvey. This year is the three hundredth anniversary of the publication of that great milestone in medicine, "De Motu Cardis et Sanguinis." With the discovery of the circulation of the blood occurred the birth of modern medicine. We can with profit reread this work not only as the recitation of keen observation, but as an example of the method to be used in approaching medical problems. One feature deserves special emphasis: not until he had labored years on this subject, demonstrated before his colleagues, and invited and answered their criticism, did he publish his conclusions; and then in a single

short monograph of seventy-two pages did he present his completed work, which ever since has stood as a model of thought, observation and deduction.

However profitable it might be, it is impractical to recite now the many discoveries in medicine of Harvey's contemporaries and successors. It is, however, important to note that the mere study of form did not satisfy most of these investigators. They were curious to learn how a structure had assumed its peculiar form; in other words, they tried to correlate form and function. Such a correlation served as a control, for if a reasonable explanation in terms of function could not be adduced for the form of a structure this was an added stimulus for inquiry further into the nature of both its form and function. Hence arose an appreciation of the value of doubt. Harvey's first chapter is a recitation of doubts; Bacon codified what must be doubted; Descartes emphasized the rôle of doubt in the words, "When we doubt, we think." These masters were interested not alone in knowledge, but in how it was to be gained and in the relationship of knowledge to life. Indeed, Descartes postulates the three means to knowledge as imagination, the senses (observation) and memory (recorded knowledge). How this corresponds with our modern conception of the scientific method will shortly appear.

Let us turn, now, to medicine, the science that most intimately concerns man, for it deals directly with his body in a state of disease. It rests immediately upon the other sciences of physiology and anatomy, which concern themselves with normal function and form, but includes both pathology, which concerns itself with abnormal function and form, and therapeutics, which in a broad sense deals with the means and methods by which pathological states may be altered or prevented. All these in turn must rest upon physics and chemistry and some upon bacteriology, but they are not physics, chemistry or bacteriology; for each science, because of the peculiarity of the phenomena with which it deals, has its own particular province. Each may borrow methods from other sciences, but must in turn develop its own hypotheses and theories.

In regarding the successes of physics and of chemistry we are liable to become discouraged because the complexity of the phenomena of disease makes our way harder, and to feel that unless we can apply the methods of the physicist and chemist in the same manner as they do ours must of necessity be a crudely empirical procedure.

Proponents of the doctrine of Emergence have, however, clearly demonstrated that the manifold forms in which matter exists make necessary the application of methods which must be adapted to the peculiarities of the immediate problem. Just as in the nebulae the astronomer or astrophysicist now recognizes the existence of states of oxygen and nitrogen which he can not reproduce in his laboratory, so in a diseased body we often have phenomena which may not be reproducible in any other place. The study of disease, therefore, even by the altering of its course by influences brought to bear from the outside, is not in any way less dignified than the study of a gas by similar manoeuvers.

Acceptance of medicine as a science, then, compels adoption of the experimental method as a means of solution of the problems presented, either in the abstract study of disease, or in the concrete study of a disease in a patient, for this method is the one that has proven the most useful in the solution of the problems in all branches of science. Even though elementary, it may be profitable to outline our conception of this method. As a result of observation of some phenomenon a question is asked. This leads to the formation of a hypothesis which is a reasonable explanation of the phenomenon. An experiment is planned and performed to test the validity of the hypothesis. If the experimental observations confirm the hypothesis it then becomes a theory; and with a correct theory we are able to prognosticate that with a given set of conditions a definite set of results will ensue. The experimental method rests, therefore, upon the tripod of observation, reasoning and experiment. You will recall that the tripod of the ancient empiricism was observation, history or record of observations and judgment by analogy. The difference between the two methods is that in the experimental method judgment is based upon experiment planned from hypothesis; subsequent action is guided by the theory so devised; whereas in the empirical method judgment is based upon analogy and is unsupported by experiment.

But in the different steps of the scientific method the technique of art must be invoked. The art of observation must be highly developed to discover the question requiring solution. The formation of a hypothesis is an art of the highest type; the hall-mark of the great scientist is his ability to formulate brilliant and useful hypotheses. A hypothesis must be reasonable, must be applicable to the question at hand and must be amenable to experimental testing. It is important to remember always that an experiment has for its object the *testing*, not the substantiation, of the hypothesis. The planning of an experiment and the manipulation of the apparatus is again an art. What we determine by this method is the relationship of one set of facts or events to another; in other words, we learn the relationships of phenomena.

As previously noted, a great difficulty in experimental medicine, and all medicine is experimental, rests on the complexity of the animal body. For ex-

perimental purposes it is necessary as far as possible to analyze the various phenomena into simple relationships, but to approximate the truth about the whole it is necessary to synthesize our analytical data into a picture which will best explain the conditions. Such a synthesis is a great art, for only the ability to picture accurately and to differentiate primary from secondary phenomena and to distinguish causal from concomitant relationships in complicated vital reactions gives us the power to alter their course.

A moment ago it was stated that all medicine was experimental. By this it was meant to imply that it is necessary for the physician, whether in the laboratory or at the bedside, to approach his problem from the experimental viewpoint. Only by postulating that we know all about a disease or all about a sick man dare we conclude that we have the necessary knowledge which will enable us to control all the symptoms, that is, the phenomena of disease. No one would be so rash as to claim such knowledge. Why, then, should he be so bold as to approach either a sick man or the problem of disease in any attitude but that of the scientist?

Just as in the formation of a hypothesis we make observations and often apply previously established theories, so in the making of a diagnosis we observe, state a question, form a hypothesis and see if the conditions observable confirm our hypothesis. If not, we go back and form a new one and make new observations, until finally our working hypothesis or diagnosis gives us sufficient assurance to permit us to try the experiment of treatment. Every treatment is a therapeutic trial. In some conditions we have sufficiently well-established theories to permit a fair prognostication of the results to be expected from certain therapeutic measures. I say fair prognostication, for often we experience disappointment because we have not sufficiently complete knowledge of the complicating factors to foresee their influence.

It seems to me that to remove therapeutics from the province of medicine would eventually remove medicine from the list of sciences and leave in its place only pathology. By this it is not meant to imply that therapeutics should be the immediate end of all study, but that often manipulations of conditions whereby the phenomena of disease are altered may be one of the important modes of studying those phenomena, just as changing the phase of a compound from the solid to the gaseous state or *vice versa* by appropriate measures may furnish important information concerning that compound. The danger lies in allowing the alteration in form or phase to become the immediate and only aim of our manipulation, thus causing us to forget the nature and relationship of the changes we have brought about.

A criticism frequently brought against modern medical education is that there is not enough systematic teaching of the art of medicine or of therapeutics. Strictly speaking, it is doubtful whether the art of medicine ever has been taught or can be taught any more than can any other art. Instruction can be given in technique and in method, models can be furnished, but the skill which we recognize as art, because of the manner in which it is exercised as well as in the final result, must be acquired by actual practice. Possibly the fault concerning therapeutics is that it is taught from the viewpoint of the ancient school of empiricism rather than from that of the modern aspect of the scientific method. If each treatment were regarded as an experiment different pedagogic results might follow. While much time is devoted in our hospitals to objective observation and recording, it is rare to see notes on the history charts which state why a certain drug was given, what effect was expected and whether or not it was obtained. In other words, it is not customary to record the hypothesis which determined the therapeutic experiment, an observation of the effect and a criticism of the results. It is probable that if the scientific method were applied more rigidly to therapeutics, the latter would assume a more dignified position both as an art and as a science.

The existence of any type of art presupposes the existence of artists. No artist can be very eminent without knowing the fundamentals of his art. The fundamentals of medicine rest in the science of medicine. We have already noted how the scientific method is essentially an artistic method; there is required successively the art of observation, of ideation in the formation of the hypothesis, of experimentation in testing the hypothesis and of synthesis in correlating the observed phenomena. In the process certain rules can be formulated, but they are merely those of logic which provide the technique of correct thinking. But no rules can be formulated to determine just how an artist shall use his materials. In putting these together in the proper manner he expresses his art and himself.

Because of man's complex mind and many potentialities the physician is brought into contact with a multitude of human activities. In so far as any of them has a direct bearing on his immediate problems he must consider it, but it is always necessary to disregard some and to emphasize others.

The vastness of nature has forced upon man the necessity of adopting the experimental method in questioning nature. This is the method of analyzing, of ascertaining details—often unrelated. But it is the harmony of nature that we wish to understand. Harmony postulates relationships, not individual tones, not mere sensation. Many modern artists seem

only to aim at producing certain sensations, without regard to harmony or beauty. Many scientists have considered it their task simply to analyze certain phenomena, functions or sensations, without any regard to the relationships of these phenomena to others. Other eminent scientists, however, are questioning the value of isolated observations made without regard to relationships. It is necessary to keep constantly in mind that analysis and synthesis should not be mutually exclusive, but rather mutually cooperative.

The worship of organization in this country has many dangers. To do big things, to encourage economic mass production, we form big machines, which work more or less automatically. A man at certain places in the machine performs certain motions which it can not be made to perform. But in doing this he becomes the slave of the machine; his actions depend upon those of the machine and hence become merely mechanical. In organizing hospitals, group clinics and educational institutions, there is a comparable danger. Each individual has a set task and a rate of motion imposed upon him by demands of the rest of the organization; this consumes so much of his energy that there is little left to apply to independent thought. Machines and organizations should do man's work and not his thinking; they should release his energy so that he may think. When they consume his energy and inhibit his thinking they are a menace rather than an aid to progress. Because applied science has made possible these wonderful and fearful machines with their consequent demands, many persons are asking to-day whether science, which has made them possible, has not failed in its object to better man's condition. They recognize that materially he may be more comfortable, and physically more healthy, but ask whether mentally he is superior to his predecessors and whether he has retained his freedom. We as scientists must face these questions and honestly try to determine wherein lies the fault. Have we in our zeal for analysis been trying to make science do too much? Have we allowed it to exclude certain elements present in the world and in man and as yet beyond its domain? Have we forgotten that its chief function is to answer the immediate *how* rather than the ultimate *why*? Is it not necessary to try to be artists in syntheses as well as scientists in analyses?

A strong feeling has also developed that science is not a part of general culture, but that art and the humanities represent the cultural side of man. In this attitude it is often forgotten that science in the past has played an important rôle in providing material for the artist. Knowledge of man's body, of his environment or of the universe is no less a part of real culture than is knowledge of man's past efforts. But is this exclusive attitude the fault of the humanities or of science? I venture to suggest that it is because the representatives in each field refuse to allow their own discipline to articulate or to come into contact with the other. In other words, there must be more working together with what all hold in common, and each must allow an influence to be exerted by what the other possesses as peculiarly his own. We must try to be artists in our syntheses and attempt to develop harmony from our mutual efforts. A few lines and pigments properly applied may produce a more effective picture than thousands of lines and much paint; on one page a poet may express a truer relationship than a scientist does in a monograph. The great requisites are the proper selection of material and imaginative synthesis to express what the artist sees. All human activities must mutually influence one another by expressing truth as we best can know it. This idea has doubtless been made articulate many times, but probably never better than by Plato, who defines science as the discovery of things as they really are, and further states, "Now when all of these studies reach the point of intercommunication and connection with one another and come to be considered in their mutual affinities, then I think and not till then will the pursuit of them have a value."

And so in the field of effort called clinical investigation we should constantly keep in mind the relationships of its various elements. The science of medicine should furnish us with knowledge and a technique for acquiring more knowledge. Although the art of medicine may indicate the manner in which that knowledge may be applied it should also assist in the technique for acquiring new knowledge. Because science can give us only a partial description of our universe, art must be ever at hand to supply the deficiency. Not all the art of medicine is at the bedside, nor all the science of medicine in the laboratory. In our respective activities the skill with which we mingle the two will determine our success.

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QUANTITATIVE VS. QUALITATIVE STUDIES IN GEOLOGY[1]

IT has been quite habitual among geologists to record relative or qualitative accomplishment in geologic processes. We say "this topography is older than that," "resistant rocks weather more slowly than soft ones," "this volcano has erupted more than that," but we are not able to say how old in years or geologic periods either piece of topography is, how

[1] Presented to the Geology Section of the Ohio Academy of Science, Cincinnati, April 6, 1928.

fast either rock weathers or how long any volcano has worked to build its cone.

Qualitative studies must needs come first, and no doubt we shall do qualitative work for many years yet; but I want to show in this paper some of the places in which much more accurate studies can be carried on. Our qualitative work has been excellent and large in amount and has laid the lines for valuable deductions and stimulating interpretations, but it is time for us to turn over a new leaf in the nature of our investigations. Stimulated by chemists and physicists who have been measuring quantitatively for many years, let us greatly expand our activities in making accurate determinations of our geologic processes, of their rates of accomplishment and of their degree of continuity and variation in rate of performance.

Geologists have already done several things quantitatively. Crystals have been carefully measured and their unknowns calculated to the fourth decimal place or the seconds of arc. Chemical analyses of minerals and rocks have been made in great numbers. Mineral analyses of rocks have been done with considerable exactness. Stream measurements have been made revealing the actual velocities and volumes and changes in both elements, also showing the amount of matter carried in suspension and in solution.

For a number of years very careful quantitative observations have been made in the field of volcanism at the crater of Kilauea in Hawaii. The printed sheets issued each week may become a little monotonous, but they are telling how many earthquakes occur each day or week, how they are distributed in time, how intense or feeble they are and their probable distance from the observatory. They record the slides in the pit, and the "working" of the floor and walls of the pit, the number of millimeters cracks have widened in a week, the colors and change of colors on the sides and floor of the pit. They tell of the displacement of bench marks as the volcano heaves and writhes in its development; they state how much the surface tilts day by day both in direction and in amount down to small percentages of seconds of arc. The studies endeavor to correlate the various volcanic phenomena with each other and with non-volcanic phenomena, as with tides and tide variations, with changes in atmospheric pressure, with earth disturbances in other places. Of course this sort of study and record will catch all the spectacular phenomena, but it is the infinite detail and accuracy of these routine items that in the long run will give us a new and better understanding of volcanism at Hawaii.

We have measured the rate of recession of falls in a few instances. Every one knows of the careful work covering a hundred years that has been done on Niagara. But here the object was as much or more to develop a measuring stick for geologic time as it was to get at the rate of progress. Two or three other falls have been similarly studied.

Twice have valleys of small streams been studied. Measurements of the actual erosion occurring in a given time in a limited part of the stream and valley were made; then careful measurements of a larger section of the whole valley were made and the two results set down in ratio. Again the study was made in each case much more to acquire a measuring stick for postglacial time than to disclose just what the stream is doing in the nineteenth or twentieth century.

Nearly thirty years ago a considerable series of observations were made on artificial structures in and around greater Boston. The observer was able to find the dates of making the structures and the condition of the structure when made. He then took photos and conducted measurements of the structures and estimated what nature had been able to do in known periods of years. Walls had been heaved or bulged, slopes had crept, flagstones had been worn, monuments weathered almost to the effacement of inscriptions and scores of other changes had been made. These were accurate measurements of actual processes in geology.

But the very fact that we can and do single these little programs out and thus exalt them is ample evidence that we are not in the habit of thus seeing quantitatively.

Why shouldn't we measure scores of falls in many kinds of rocks and under different climatic conditions and leave our records for some successor? Then he could repeat the measurements and from the two series deduce conclusions. Why can't we measure many postglacial, as well as other, streams with their valleys in drift or in coastal plain rocks or even in crystallines and file our results with some permanent institution, and let some one else repeat the measurements in fifty years and check up on rates of work? This study need not be done solely to get a time measurer but to learn rates of work.

Nearly twenty-five years ago a member of the United States Geological Survey spent some time with surveyors in the Great Lakes region tying in a series of accurate bench marks with the lake levels. He has gone on. His records are in the survey archives. I believe the plan is to have the bench marks and lake levels again surveyed in some twenty-five or twenty-six years more and the results checked against the earlier survey. It is said that if there is a tilt of an inch in one hundred miles in any direction these observations will detect it. Then we shall know if the Great Lakes area is in motion in the first half of the

twentieth century; the direction and amount of motion if detectable will also be made manifest. Now why not do this sort of thing in many places? Shore-lines of long bays, the Baltic, Adriatic, Gulf of California and Chesapeake Bay would be serviceable.

Dr. Karl Sapper said not long ago, "The most important goal for the future of volcanology is to obtain new collections of facts and make them available, for only by such procedure can a substantial basis be made for more satisfactory interpretations than have hitherto been invoked." Why not extend the careful quantitative study of volcanoes now under way at Hawaii to at least a score of volcanoes in different types of regions, with diverse character of eruption, other kinds of rock magma and other relations to land and sea? Such a series of observations over a period of fifty years would help to reach Dr. Sapper's suggested goal. How can we expect to make much further progress in volcanology on qualitative observations and these limited to a half dozen volcanoes? We are not cultivating the field anything like as intensively as many of our agriculturists work theirs.

What do we know about viscosity of lava? Several statements from recent works are quoted below. "Lavas low in silica may flow like water, lavas high in silica are more viscous." "As cooling progressed viscosity or stickiness of the substratum kept increasing." "The increasing pressure (toward the earth's center) could not fail to develop high viscosity."

The author gives no reference, no evidence and no measurements, nor are there given in any of the above references a suggestion even of a ratio, to say nothing of the actual rates and values. Some of these items may be subjected to experimentation. Rate of flow of different lavas could be measured, at determined temperatures, and with calculated cross-sections and gradients; then the values could easily be checked against the calculated or measured rate of water flow under similar conditions. The viscosity of water is known. Then we should have some specific ratios, with actual values in them.

Possibly we could study the viscosity of lavas made up with specific compositions and heated to desired temperatures. The following statement is taken from a well-known text-book. "Where the saturation (of the water) is but little above that of average ocean, animal life becomes scarcer and Molluscs make thicker and rougher shells." It seems simple to test the matter out and see how much the saltiness has to be increased to make certain appreciable reductions in the numbers of animals, and to ascertain how much thicker and rougher molluscan shells become with definite increases in the saltiness of the water.

We have a considerable number of meandering streams of various sizes and on various grades with measurable velocities, loads and volumes. It would be instructive to make quantitative studies of say twenty or thirty streams over a period of years to learn the rate of growth of meanders under the several conditions, the rate of migration of meanders, the size attained by meanders in the different streams before they cut themselves off, the frequency of meanders and other items on the behavior of meanders. We shall never be able to meet successfully the problem of Mississippi River control until some one knows quantitatively much more of the physiography of the river.

The mechanics of faults have been worked out pretty largely on an empirical basis. Let us now measure the rate of movement, direction of movement, frequency and continuity of movement along several active faults and thus add somewhat to our knowledge of faults and possibly as much to our ability to interpret them.

Rocks weather at vastly different rates. What is the rate of solution of limestone? Of dolomite? What is the rate of weathering of feldspars? Of olivine, hornblende or enstatite? By controlling conditions and making regular accurate measurements we can add to our knowledge of weathering.

We have often made estimates of the rate of sedimentation of sands for sandstones, clays for shales, and calcium carbonate for limestones. It is now possible to make accurate measurements of the depth of water in lakes, marshes and shallow seas, then resurvey after a period of years, and thereby to discover the actual rate of sedimentation under these conditions. One such study would be valuable, but a score of them would remove some of our guesswork and crude estimates. Some of the Finger Lakes in New York State, western Lake Erie or Ontario in parts might be thus studied. Lakes in Europe would also be admirable for such studies. Chesapeake Bay would seem to be a promising sea to investigate. Lake Pontchartrain has an interesting story to tell. Reefs off the coasts of Florida, Cuba, Yucatan and the Bahamas might give good results on the rate of reef building.

Shore-lines can be carefully surveyed or measured both where cliffs occur and where beaches are building, as well as along delta fronts. New surveys fifty or one hundred years after would give worth while checks on rates of progress. Most of our knowledge of such matters is couched in such terms as "rapid erosion," "slow building forward" and "intermittent cutting and filling along the beach."

Of course no one man could complete any of these studies, but institutions could initiate them and carry them on. Individuals could make first surveys and will their programs and data to some institution able

to take the work over. Then some other man could later continue the work. Some of these problems should be carried forward at intervals for hundreds of years. It is a long look ahead, but geology, which gazes far back, should also have courage to plan far ahead.

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GENTLE SOUTHWEST WINDS

There had been a chill easterly breeze all day, which to a person perhaps abnormally apprehensive had been a source of fear that his plans for to-morrow's outing might be upset, but the evening paper carried the reassuring forecast: "Fair and warmer, gentle southwest winds." In the morning waking up by the light rather than by the clock one finds it already late with a driving rain against his windows and a northeaster blowing forty to fifty miles an hour in the stead of that five- to eight-mile soothing southwest zephyr. True, the mathematician will tell us that -50 is much less than $+8$, but is it gentler? The plans are indeed upset with only a cynic's humor to relieve the disappointment as he reads in the breakfast newspaper the forecast for to-day: "Fair and warmer, gentle southwest winds."

There are two things to observe about this forecast. First, however it may have been from the viewpoint of the meteorologist who made it, from the viewpoint of the reader it is not a forecast but a plain contradiction of the actual condition. Does not the forecaster unnecessarily expose his reputation by permitting this observation to be made? Should he not take a leaf from the notebook of the long-range weather expert and talk only of the future, that which ordinarily will be future to the reader of the forecast, so that his errors will not strike so many so obviously? And, second, is the forecast properly to be called erroneous; may it not be that, superposed upon the general flux of meteorologic conditions, which is subject to such law as may let forecasting aspire to be scientific, there is an essentially hazardous element of more or less local instability which will forever in part cheat the aspiration of its fulfilment?

Those who watch the typical local thundershowers of the summer play hide and seek with the sun know that the precipitation is brief in time and very spotty in place. Many do not so well realize that even in a general wide-spread rainstorm the precipitation comes often in spurts which last but a short time and are therefore to be presumed to be distinctly local. This phenomenon shows itself on the records even of the annual rainfall.[1] Consider the table of six stations in the city of Providence,[2] R. I., for the years 1921-1925.

The first five rows in the table give the records under municipal auspices at the Hope, Fruit Hill and Sockanosset reservoirs, the Pettaconsett pumping station and the sewage precipitation works. That record which in each year is highest or lowest is marked H or L; that year which at each station is highest or lowest is marked h or l. The yearly means for the five stations and the difference between high and low are next given. This difference varies from 2.7 to 9.4 inches, with a mean of 5.0. Yet if the records for the five years be averaged the difference H-L is only 1.9. The range of the yearly means is 10.5 inches. Furthermore, the highs and lows (H and L) distribute themselves haphazardly among the stations. These facts show that, so far as this brief record of these five stations goes, we may well consider that the variations between the stations are fortuitous each year, that as precipitations are measured to .01 inch the variations between the stations must be regarded as real and of about one half the extent of the variations from year to year, that the driest year was 1924, according to Hope and Fruit Hill, but 1925

[1] See the discussion by A. McAdie, "Dry and Wet Seasons," Blue Hill Annual for 1923.

[2] The figures for precipitation are given in the exhaustive tables by X. H. Goodnough, "Rainfall in New England," J. N. E. Water Works Assoc., 29, 239–432, 1915; 35, 228–293, 1921; 40, 178–247, 1926.

Precipitation in Providence, R. I.

Station	Elevation	1921	1922	1923	1924	1925	Avg.	h–l
Hope Reservoir	162 Ft.	46.5H	49.0h	27.7	37.8Ll	39.0	44.0	11.2
Fruit Hill	275	44.2	53.7Hh	44.7	38.4l	40.0	44.2	15.3
Sockanosset	182	44.6	48.8L	49.3h	42.9H	41.5Hl	45.2H	7.8
Pettaconsett	25	45.1	49.1h	40.4L	42.5	39.2l	43.3L	9.9
Sewage Works	25	43.6L	50.2h	49.8H	42.1	38.8Ll	44.9	11.4
Mean		44.8	50.2	46.4	40.7	39.7	44.3	
High–Low		2.9	4.9	9.4	5.1	2.7	5.0 or 1.9	
U. S. Weather Bur.	182	36.8	44.9	40.8	33.5	33.6	37.9	
Mean—U. S. W. B.		8.0	5.4	5.6	7.2	6.1	6.4	

according to the other three stations, that the wettest year was 1923 at Sockanosset but 1922 at the other four stations. Indeed, the fluctuations from station to station and from year to year are so great that obviously a very long series of years and a considerable number of stations should be available before one has the material necessary for statistical analysis and sound inference. For example, was 1924 or 1925 the drier year in Providence? All the record enables us to say is that we do not know.

When we look at the figures of the Weather Bureau we see at once that they are running lower than those of the other stations. No complicated statistical criteria are necessary or useful for this conclusion. In each year of five they are lower than the means of the other stations; by chance this would happen only once in 2^5 to 32 times, provided there were no systematic difference, and we take odds of 32 to 1. The difference between the Weather Bureau and the means of the other five runs about 15 per cent. Systematic variations as high as 15 per cent. in the measurement of precipitation by different gauges are known[3] and make it necessary that if figures for precipitation are to be compared at different times and in different places a good calibration between the recording instruments should be available, and this calibration should be by direct comparison, because owing to the showery nature of precipitation a very long series of observations at different places even within the same large city would be necessary to establish the calibration by a statistical reduction of the observations themselves, and even then there would be no assurance that part of the residual systematic difference were not due to difference of elevation or other dissimilarities in the configuration of the local terrain.

The six stations in Providence have a seventeen-year record in common (1909–1925). We shall not give the figures[2] in detail here; but some deductions from them may be mentioned.

	Hope Reservoir	Fruit Hill	Sockanosset	Pettaconsett	Sewage Works	Mean	U. S. W. B.
17-year mean	44.5	42.4	43.6	43.4	42.4	43.3	37.1
Standard deviation	6.0	5.4	5.0	5.5	4.8	5.3	4.2

The seventeen-year means place Hope highest and Fruit Hill and the Sewage Works tied in lowest place. The standard deviations for the five stations vary from 6.0 to 4.8, about a mean of 5.3. The seventeen-year means have a mean of 43.3 and vary about that with a standard deviation of 0.8. Is there a real difference of significance between the stations? We must bear in mind that we are dealing with a double series. If we take only one station for the seventeen years with the standard deviation from year to year about 5.3, we infer that the means of seventeen-year samples may vary by $5.3/4.1 = (\text{S.D.}/\sqrt{17}) = 1.3$ and thus the value of the mean at that station is not particularly well determined and the five means would be too near together. But the five seventeen-year series are of course highly correlated (and highly correlated with that of the U. S. Weather Bureau, which falls below them by 15 per cent.). The coefficients are:

	Hope	Pettaconsett	Sewage	Sockanosset	Fruit Hill	U. S. W. B.
Hope	—	.86	.85	.84	.81	.83
Pettaconsett	.86	—	.75	.92	.84	.76
Sewage	.85	.75	—	.87	.82	.90
Sockanosset	.84	.92	.87	—	.81	.77
Fruit Hill	.81	.84	.82	.81	—	.83
U. S. W. B.	.83	.76	.90	.77	.83	—

The mean coefficient is .83 and the S.D. of the fifteen coefficients about this mean is .046.

It is the standard deviation of the station values about their yearly means or that of the differences of the values for the same year between the ten pairs of stations which should be examined to find the sampling error as between the stations in the seventeen-year means. The former value is 2.1, the latter 3.2. For the five means the corresponding values are .8 and 1.3. Now random samples of seventeen should differ from the mean by $2.1/4.1 = .5$ or from each other by $3.2/4.1 = .8$. The observed values differ by 50 per cent. more, which indicates that in fact the stations do differ among themselves more than might be expected and that therefore some of the difference observed between them may be real, but the significance of the amount of this difference is very poorly established[4] as even the largest of the ten differences

[3] See Goodnough, *loc. cit.*, 1926, pp. 179–184.

[4] Although, owing to the magnitude of the interstation fluctuations, the quantity by which the Hope Reservoir record exceeds that of the Sewage Works is not very definite, the qualitative fact that Hope is running high is well established by the simplest of criteria. For, if there were no tendency to run high, being one of five stations the chance that it should be highest in a particular year

must be written 2.1 ± 0.8. Such considerations justify the earlier statement that a very long statistical series is necessary to calibrate one instrument against another, unless the observations are performed at the same spot.

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SCIENTIFIC EVENTS

A CHINESE NATIONAL RESEARCH INSTITUTE

THE founding of a National Research Institute modeled on the Smithsonian Institution was one of the first acts of the new Nationalist Government in China. Dr. Chi Li, field archeologist of the Freer Gallery, has issued a statement in regard to the work of the institute, which is in part as follows:

The purpose of China's national research institute is expressed in a phrase borrowed from the Smithsonian Institution—the increase and diffusion of knowledge. The institute has already organized an expedition to the Province of Kwang Si, to study the geology, paleontology, zoology and botany of the province. The expedition hopes also to include eventually anthropology and archeology in its scope. The cost will be shared by the national government and the provincial government of Kwang Si. The institute hopes in this way to develop systematic scientific exploration of every province in China.

The membership of the institute includes thirty well-known scientific men. Dr. Li represents archeology and was the first member of the new organization. He will continue as field representative of the Smithsonian Institution and the Freer Gallery.

The most productive native institution, according to Dr. Li, has been the Geological Survey of China, organized about twelve years ago. Its geological, paleontological and archeological reports are internationally known.

The Smithsonian Institution plans to cooperate actively with the new institute, and Dr. Li will see the Nationalist authorities at Nanking on his return to China to work out a method of cooperation. It is Dr. Li's opinion that the new growth of national self-consciousness has considerably brightened the outlook for foreign cooperation in scientific research in China.

I consider science the most powerful agent for international understanding [said Dr. Li]. In my own case I feel more at home with an archeologist, no matter what his race, than with one of my own countrymen whose interests are not my own.

In sketching the history of modern science in his country, Dr. Li said that the first national activity of importance began with the founding of the Chinese Republic in 1912. Shortly thereafter a science society was organized to diffuse the scientific knowledge accumulated by the western world. In 1920 a biological laboratory was established at Nanking, and a movement is on foot to establish a second laboratory at Peking.

THE BRITISH EMPIRE VEGETATION COMMITTEE

PROFESSOR A. G. TANSLEY, F.R.S., and Dr. T. F. Chip, of the Royal Gardens at Kew, president and secretary, respectively, of the British Empire Vegetation Committee, have sent out a letter announcing the intention of the committeee to put into effect a resolution passed in 1924 by the Imperial Botanical Conference, to the effect that all future work published on the vegetation of the British dominions and colonies should be registered and abstracted, the abstracts being made generally available by periodical publication.

By the courtesy of the British Ecological Society, publication of these abstracts will take place by way of supplement to *The Journal of Ecology,* which is published twice a year, and of which Professor Tansley is the editor, and this supplement will appear as a part of each number. The supplements will also be obtainable separately from the rest of the journal. It is hoped that all botanists will cooperate with the committee by supplying proofs or separates and preparing abstracts of any of their publications that may bear on the subject, beginning with January, 1927. It is requested that abstracts should not exceed in length from three to five per cent. of the book or paper abstracted; in many cases considerably shorter abstracts will be adequate. At the same time it is realized that in the case of new and important results of detailed ecological or vegetational work longer abstracts may be found necessary. A description of the plan for making and despatching abstracts will be mailed on request by the secretary of the committee.

FEDERAL AID TO AGRICULTURE

IN a speech on federal aid for agriculture before the Round Table on Agriculture at the Institute of Public Affairs, University of Virginia, on August 8, which is reported in the *U. S. Daily,* Eric Englund, senior agricultural economist in the Department of Agriculture, pointed out that, although the Depart-

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is $\frac{1}{2}$ and the chances of different numbers of highest could be obtained from the expansions of $(\frac{1}{2}+\frac{1}{2})^{17}$. Now Hope was highest in nine years out of seventeen and the chance for a score so high as this is about 1 in 400—even the chance that some one of five stations should have such a score is only about 1 in 80. In a similar way one may examine the fact as to whether a station is above or below the mean of the five by considering $(\frac{1}{2}+\frac{1}{2})^{17}$, but the criterion is not so discriminating.

ment of Agriculture has a total fund of $155,059,-968.43 for 1928, the greater part of this can not be classified exclusively as aid to agriculture, since nearly 56 per cent. of the amount is for such purposes as federal-aid highways. Of all revenue of the agricultural experiment stations in 1889, only 18 per cent., in round figures, was obtained from within the states, and 82 per cent. from the federal government; by 1910 and 1925 the proportion of state support had advanced to 62 and 86 per cent., respectively. In 1927, notwithstanding the fact that federal support for each state had been increased by $30,000 under the Purnell Act, the stations received 77 per cent. of their support from within the states and 23 per cent. from the federal government.

In other words, federal aid for agriculture through scientific research in the experiment stations increased from $585,000 in 1889 to $2,880,000 in 1927, or about five-fold, while support for the stations from within the states increased from $125,000 to $9,768,000, or seventy-eight fold.

Federal funds for research in the Department of Agriculture in 1927, aside from the support for state experiment stations, amounted to nearly $10,600,000, exclusive of research in forestry, wild-life conservation and highway construction. In that year federal support for research roughly classified as directly and specifically related to agriculture in the department and in the experiment station amounted to nearly $13,500,000.

The more controversial subject of federal aid under the "50–50 system" includes agricultural extension, vocational education in agriculture and road construction, which, as already noted, is of general public importance. State funds for these purposes greatly exceed the federal support.

In 1925, nearly $19,700,000 was spent for cooperative extension work, of which 62 per cent. was derived from sources within the states and 38 per cent. from the federal government. Of the federal contributions of $7,400,000, the states were required under the terms of the Smith-Lever Act to match only $5,400,-000. Hence, in 1925, the states contributed $2.27 for every federal dollar that had to be matched to make it available for agricultural extension in the states.

The support for vocational agricultural education under the Smith-Hughes Act in 1927 amounted to $7,500,000, of which $2,800,000, or 38 per cent., was supplied by the federal government.

RESEARCH IN AVIATION

RESEARCH now being carried on in the fields of aerial communication, instruments and meteorology by various branches of the government and by private concerns will be coordinated by a standing committee of the National Advisory Committee for Aeronautics.

Members of the committee have been appointed as follows:

Dr. Joseph S. Ames, of the Johns Hopkins University National Advisory Committee for Aeronautics, chairman; Dr. L. J. Briggs, Bureau of Standards; Paul Henderson, National Air Transport, Inc.; Dr. J. C. Hunsaker, American Telephone and Telegraph Company; Captain E. S. Land, Daniel Guggenheim Fund for the Promotion of Aeronautics; Colonel Charles A. Lindbergh, G. W. Lewis, National Advisory Committee for Aeronautics; Professor Charles F. Marvin, United States Weather Bureau, and C. N. Young, aeronautics branch of the Department of Commerce. J. F. Victory, secretary of the advisory committee, also is secretary of the committee.

The subcommittee studying problems of aerial communication, headed by Dr. J. C. Hunsaker, will cooperate with other organizations at present conducting research along the same lines, including the American Telephone & Telegraph Company, the Bureau of Standards, the War Department, the Navy Department and the Radio Corporation of America.

Dr. L. J. Briggs will be in charge of the subcommittee studying instruments, which hopes to bring about by its research the development of better and more accurate instruments for aerial navigation.

A subcommittee studying meteorology, headed by Dr. Charles F. Marvin, plans to work with the committee recently established by the Guggenheim Fund to study the problem of fog landing. There already are three extending major committees of the Advisory Committee. These are the committees on aerodynamics, power plants for aircraft and materials for aircraft.

AN AKELEY MEMORIAL IN THE BELGIAN CONGO

THROUGH Prince Albert de Ligne, ambassador to the United States, the Belgian government, as reported in the New York *Evening Post,* has requested permission to place a commemorative tablet of bronze on the tomb of Carl Akeley, African explorer, who lies buried where he died in the Belgian Congo.

M. Caspar, prime minister of Belgium and minister of the colonies, said in making the request: "This action is desired as a token of the admiration of the Belgian government for the great American scientist."

Carl Akeley died suddenly on November 17, 1926, on the slopes of Mount Mikeno, in the Parc National Albert of the Belgian Congo, where he and Mrs. Akeley had undertaken to fulfil a mission from Albert, King of the Belgians. Mrs. Akeley, aided by the other members of the party and her black boys, prepared his grave in the solid volcanic rock and, using the only available materials, built a coffin of

native mahogany, metal-lined and upholstered with soft woolen blankets.

An eight-foot stockade of mahogany posts was erected around the burial plot to prevent the encroachment of the jungle. A great slab, made of cement, which Mrs. Akeley caused to be brought from a government post, a hundred miles distant, bears the explorer's name and the date of his death.

The bronze tablet which the Belgian government now proposes to dedicate to Mr. Akeley's memory will surmount this cement slab. On a future expedition Mrs. Akeley plans to supervise the placing of the tablet on her husband's grave.

After her husband's death Mrs. Akeley was made leader of the expedition by the American Museum of Natural History. She remained at an altitude of 12,500 feet for seven weeks on Mount Mikeno in a camp by her husband's grave, there to complete the survey of the Parc National Albert and to proceed with scientific observations on the mountain gorilla and his environment begun by Mr. Akeley in 1921.

In recognition of her successful completion of the mission, Mrs. Akeley on her return to Brussels was decorated by the King of the Belgians with the cross of Knight of the Order of the Crown. She is now an adviser in the Carl Akeley African Hall work at the American Museum of Natural History.

SCIENTIFIC NOTES AND NEWS

PROFESSOR ALBERT A. MICHELSON, of the University of Chicago, is now in Pasadena, where he is recovering from a surgical operation that he recently underwent in Chicago. He expects to resume soon his work on the measurement of the velocity of light.

DR. SHIRLEY W. WYNNE, deputy health commissioner of New York City, has been appointed commissioner, to succeed Dr. Louis I. Harris, who recently resigned to accept the position of consultant to the National Dairy Products Corporation.

DR. GEORGE C. RUHLAND has been appointed commissioner of health of the city of Syracuse, at a salary of $10,000, succeeding Dr. Herman G. Weiskotten, dean of the college of medicine of Syracuse University, who resigned on August 1. Dr. Ruhland, who since 1924 has been deputy commissioner, is to give his whole time to the work.

DR. EDWIN O. JORDAN, professor of bacteriology and chairman, department of hygiene and bacteriology, University of Chicago, has been appointed Cutter lecturer on preventive medicine at Harvard University for the year 1928–29.

THE National Tuberculosis Association awarded the Trudeau medal to Sir Robert W. Philip at the time of the annual meeting held recently in Portland, Oregon. Sir Robert W. Philip is a fellow of the Royal College of Physicians of Edinburgh.

A FAREWELL dinner has been given at the University Club, Cleveland, by members of the staff of St. Luke's Hospital to Dr. Henry R. Muller, who is leaving for the Rockefeller Institute, New York, to take up some of the work in which Dr. Noguchi was engaged at the time of his death.

IN honor of the seventieth birthday of Dr. Sidney Young, professor of chemistry at Trinity College, Dublin, the following address was presented to him in the presence of a group of distinguished scientific men: "We, your fellow chemists, colleagues and students, past and present, desire to convey to you our congratulations on attaining the age of seventy years, and to wish you a more prolonged enjoyment of good health and the occupation of your chair. We desire also to put on record our appreciation of your fundamental researches in physical chemistry, more especially those concerning pure liquids by fractional distillation, and your determination of their critical contents; nor would we leave unmentioned your lectures in Bristol and in Dublin."

THE honorary degree of doctor of philosophy has been conferred upon William E. Weiss, of Wheeling, W. Va., one of the founders and general manager of Sterling Products, Inc., by the University of Cologne, Germany, in recognition of his services as an intermediary between German and American pharmaceutical staffs.

DR. F. AGUILAR, founder of the dental school in the College of Medicine of Madrid, has been given the title of Viscount de Casa Aguilar by the government. This is said to be the first time that a physician has been so honored.

E. P. WIGHTMAN, research chemist at the Eastman Kodak Co., Rochester, N. Y., has been admitted to a fellowship in the Royal Photographic Society of Great Britain.

DR. SARA E. BRANHAM, for the past year associate in bacteriology in the University of Rochester School of Medicine and Dentistry and formerly instructor in bacteriology at the University of Chicago, has been appointed associate bacteriologist in the Hygienic Laboratory of the United States Public Health Service, Washington, D. C.

CAPTAIN EMORY S. LAND, assistant chief of the bureau of aeronautics, of the Construction Corps of

the United States Navy, has been appointed vice-president of the Daniel Guggenheim Fund for the Promotion of Aeronautics. The Navy has released Captain Land for the period of one year.

A. M. ERSKINE has resigned as professor of chemistry at Hamilton College, Clinton, N. Y., to accept the position of assistant technical director of dry color research with E. I. du Pont de Nemours & Co., at its Meadows Plant, Newark, N. J.

IT is announced in *Nature* that Dr. E. F. Armstrong, having resigned his position as a director of British Dyestuffs Corporation, Limited, has accepted a retainer as consultant to Imperial Chemical Industries, Ltd.

IT is planned to establish in London a Kodak Research Laboratory similar to the research laboratory of the Eastman Kodak Company, at Rochester, N. Y. It will be part of the kodak factory organization at Harrow, and will be under the direction of Walter Clark, a well-known photographic worker, who was at the British Photographic Research Association for five years, and was later connected with the South Kensington Museum.

A CONFERENCE was recently held at the Jacques Loeb Laboratory of Physiology at Pacific Grove, California, by Professor W. E. Allen, of the Scripps Institution of Oceanography of the University of California, at La Jolla; Professor L. B. Becking, chairman of the subcommittee on fundamental marine biology of the International Committee on Oceanology of the Pacific, and Professor H. B. Bigelow, of the Harvard Museum of Comparative Zoology, for the purpose of discussing the most promising possibilities of cooperation among various scientific organizations of the nation in study of the floating plant and animal life of the Pacific, particularly with reference to problems along the North American Coast.

AT a joint council meeting of the People's League of Health, London, July 12, a resolution was passed urging the league to bring to the attention of the government the need for the control of preventable noise in the streets. The following members of the medical council have been asked to form the deputation to present the subject to the ministry of health: Sir Edward Farquhar Buzzard, Sir Maurice Craig, Sir Robert Armstrong-Jones, Sir James Purves-Stewart, Dr. Alfred F. Tredgold, Dr. Thomas Beaton and Dr. G. Robertson.

THE Ross Institute and Hospital for Tropical Diseases has organized an "Anti-Malarial Advisory Committee," with the object of assisting tropical industries in carrying out practical measures to combat the disease. The technical members of the committee are Sir Malcolm Watson, Sir Ronald Ross, Sir William Simpson, and Sir Aldo Castellani, and the lay members include representatives of a number of rubber, cotton, gold and other mining companies and associations. The anti-malaria staff at the institute will be at the disposal of these companies for advice, and it is intended that Sir Malcolm Watson himself shall visit some part of the tropics every year for a short period.

AN Associated Press dispatch states that the committee appointed to determine the best site for the proposed Boulder Dam project met in Denver on August 13. General William L. Sibert is chairman of this committee; other members are Dr. Charles P. Berkey, professor of geology at Columbia University; Robert Ridgway, former president of the American Society of Civil Engineers; Professor Daniel W. Meade, professor of hydraulic engineering at the University of Wisconsin, and Warren J. Mead, professor of geology at the University of Wisconsin.

THE International Committee for Bird Protection has engaged an active European secretary in the person of Dr. J. M. Derscheid, of Brussels. A series of lectures will be organized in France in the beginning of autumn and a wide publicity campaign in the press of Italy has been determined upon. The expenses of this international movement for bird protection thus far have been borne by the National Association of Audubon Societies, of which Dr. Pearson is president.

COLONEL E. LESTER JONES, head of the U. S. Coast and Geodetic Survey, has returned to Washington from England where he attended the International Geographical Congress in London and Cambridge. H. J. Cox, of the U. S. Weather Bureau, district forecaster at Chicago, also attended. Before sailing for home on August 15 he made a brief study of the meteorological service supplied to aviation in the British Isles, France, Belgium and Holland.

PROFESSOR HAVEN EMERSON, of Columbia University, will report on the results of prohibition from the hygienic aspect at the nineteenth International Congress against Alcoholism which will be held at Antwerp under the presidency of Professor Zunz, of Brussels, at the end of the present month.

DR. H. C. OBERHOLSER, ornithologist of the Biological Survey, spent three weeks during July studying waterfowl in Canada. In addition to field observations of waterfowl conditions, he held conferences with Canadian officials regarding organization features in the interest of the country-wide waterfowl census, which is being conducted in cooperation with Canada.

CLIFFORD POPE, assistant curator in the American Museum of Natural History, has been visiting Chicago where, with Mr. Karl P. Schmidt, of the Field Museum, he has been studying his last collection of reptiles made for the Central Asiatic Expedition in China. The collection includes about 2,600 specimens, among which are representatives of more than ninety species, nearly all of which are from Fukien Province.

DR. ROBERT BROOM, of South Africa, is visiting the American Museum of Natural History to make a further study of the specimens of the South African reptiles in the Broom collection, which was acquired by the museum fourteen years ago.

DR. J. E. WODSEDALEK, professor of zoology and dean of the graduate school at the University of Idaho, after fifteen years of service will spend a sabbatical year, primarily in research, at the University of Minnesota, where he has been made professorial lecturer in zoology.

PROFESSOR ALEXANDER SILVERMAN, head of the department of chemistry in the University of Pittsburgh, has delivered an illustrated lecture on "Recent Progress in American Glass Manufacture" before the German Ceramic Society at Dresden, Germany.

DR. JOSEPH EDWARD KIRKWOOD, professor and head of the department of botany at the University of Montana, died on August 16 at the age of fifty-six years.

DR. JOSEPH T. ROSA, Jr., a member of the faculty of the branch of the college of agriculture of the University of California at Davis, died suddenly on August 22 at the age of thirty-three years. Dr. Rosa had conducted extensive researches and had published numerous bulletins on the cultivation of potatoes, melons and tomatoes.

WILLIAM MAVER, Jr., an electrical engineer and technical writer, died on August 8 at his home in Jersey City at the age of seventy-six years.

VISCOUNT HALDANE, of Cloan, the distinguished British statesman, died on August 19 at the age of seventy-two years. Lord Haldane was the author of books concerned with philosophy and science, the most recent being "The Reign of Relativity" and "The Philosophy of Humanism." Lord Haldane belonged to a family distinguished in law and in science. His brother, John Scott Haldane, has been director of the mining research laboratory of the University of Birmingham and his nephew, J. B. S. Haldane, is well known for his work in biochemistry.

PROFESSOR JINZO MATSUMURA, for nearly thirty years director of the Botanic Gardens, Koishikawa, and professor of botany in the Imperial University, Tokyo, died on May 4, aged seventy-three years.

PROFESSOR GUNNAR ANDERSSON, professor of economic geography in the Commercial High School, Stockholm, and author of works on plant geography, died on August 5, aged sixty-three years.

FRANK STANTON CAREY, who for thirty-seven years was professor of mathematics in the University College and the University of Liverpool, died in Liverpool on July 26. Professor Carey published a number of works, including "Solid Geometry," "Infinitesimal Calculus," "Papers on Mathematics," and "Elements of Mechanics," the last in collaboration with Professor J. Proudman. On his retirement the title of emeritus professor was conferred on him by the Senate, and a sum of £240 was subscribed by friends, colleagues and past students for the foundation of the Carey prize in mathematics, to commemorate his long and distinguished work for the university.

THE contributors to the Ferrier Memorial Fund met on July 18 in London under the chairmanship of Sir Charles Sherrington, and resolved to invite the Royal Society to accept the sum of £1,000 in trust to found a David Ferrier Memorial Lecture. It was further decided that the balance of the fund shall be applied as seems best when the total contributions are known. The fund will be closed on September 30. The honorary treasurer is Dr. W. Aldren Turner, 18, Harley Street, W.1.

APPLICATION for the position of senior toxicologist at a salary of from $4,600 to $5,200 a year must be on file with the U. S. Civil Service Commission not later than September 5. A vacancy in the Bureau of Chemistry and Soils, Department of Agriculture, and vacancies occurring in positions requiring similar qualifications, for duty in Washington, D. C., or in the field, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer or promotion. Competitors will not be required to report for examination at any place, but will be rated on their education, training and experience and on a thesis or publication, of which the applicant is the author, on some subject connected with physiology, pathology, toxicology, pharmacology or biochemistry, which must be filed with the application. The applicant must be under fifty-three years of age. Application for the position of cytologist in the Hygienic Laboratory of the U. S. Public Health Service with a salary of $3,700 must also be on file on the same date. Applicants, who must be under forty-five years of age, must have been graduated from a college or university of

recognized standing with the degree of M.D., Ph.D., or D.Sc., the course to have included courses in zoology, biochemistry, anatomy and physiology; and, in addition, must have had at least three years of graduate study or research experience in cytology, preferably with relation to the action of various types of radiation on living cells. Competitors will not be required to report for examinations at any place, but will be rated on their education, training and experience.

Nature reports that the meeting of the Astronomische Gesellschaft was held at Heidelberg on July 18 to 21 so soon after the meeting of the International Astronomical Union at Leyden that a large number of British and American astronomers were able to attend. The question of the reobservation of the A. G. Catalogue by photography was fully discussed, and a number of interesting communications on various subjects were read. Dr. Max Wolf invited the members to tea at the Königstuhl, and they were shown round this observatory. The members were welcomed by the university and municipality and were entertained at a dinner, at which the rector of the university, the president of the Astronomische Gesellschaft, the Astronomer Royal, Professor Schlesinger and M. Mascart spoke. An invitation by the municipality of Stuttgart included a visit to Weil der Stadt, where Kepler was born. A wreath was placed on his statue by Dr. Max Wolf, and short addresses were given by Dr. Wolf and Professor Eddington. At Stuttgart a demonstration was given of the Planetarium. The meeting terminated with a visit to Mannheim, by kind invitation of the municipality. On the journey to or from Heidelberg many of the members, by kind invitation of Professor Kohlschütter, visited the observatory of Bonn and saw the instruments and observatory of Argelander.

AT the second International Congress of Radiology, which met at Stockholm during the last week in July, under the presidency of Professor Gösta Forsell, there was an attendance of 1,500, 1,000 of whom were registered members. It was decided to hold the third congress in Paris in 1931, under the presidency of Professor Béclère.

THE thirteenth annual meeting of the Optical Society of America will be held at the Bureau of Standards, Washington, D. C., on November 1, 2 and 3. In addition to the technical program, an exhibition of optical instruments, apparatus and products has been planned under the joint auspices of the Bureau of Standards and the society. Manufacturers, dealers and individual workers are invited to exhibit recently developed instruments and those particularly significant in research. All material to be published in the catalogue of the exhibition must be in the hands of I. C. Gardner, chairman, Bureau of Standards, Washington, D. C., not later than September 1.

THE Commonwealth Fund has begun the issuance of *The News Letter,* which will be published bimonthly beginning in October, 1928, the occasion of the tenth anniversary of the founding of this philanthropy. The introductory number issued in May describes *The News Letter* "as a vehicle through which to promote an enlarged sense of unity of purpose and to advance . . . better understanding of the purposes and objectives of the fund." One of the departments of *The News Letter* will be devoted to activities of community clinics, that part of the fund's program conducted by the Division of Community Clinics of the National Committee for Mental Hygiene.

A BILL was passed, May 24, by the Turkish national assembly providing for a central institute of hygiene, to be erected in Angora. The institute, according to the *Journal* of the American Medical Association, is to make every kind of scientific research and investigation connected with the amelioration of the health conditions of the people; to solve the problems of health and sanitation for the ministry of hygiene; to prepare all vaccines and serums and do all other laboratory work for the ministry; to examine and verify all foreign biologic preparations; to deal with general problems of hygiene and public health; to give postgraduate courses in public health and hygiene to health officers and other physicians, and to serve as hygiene and health exchange for municipal and other official agencies. All work done by the institute for municipal and other official agencies shall be free of charge. The prices of all preparations of the institute laboratory are to be fixed by the ministry of hygiene. The minister of hygiene is authorized to appoint specialists from foreign countries for the new institute. The government has granted the sum of 2,000,000 Turkish pounds for the construction of the institute and the departments. The chemical and bacteriologic building has already been completed, and the construction of the school of hygiene and public health is to commence within a few months.

THE use of weights and measures other than metric are to be prohibited in Mexican trade under a law signed recently by the president. Under the proposed regulations all articles would have to be sold by weight, measure or volume, and such units would have to be in the metric system; this would prohibit the sale of "package" goods as such. It is also proposed that sales be in units or multiples of one, two or five of some metric unit.

A COMPREHENSIVE state-wide program of wild life conservation has been undertaken in Missouri. To provide places for raising deer, wild turkey, quail and pheasants, and likewise provide camp grounds in the Ozark Mountain district, the state has purchased 36,000 acres of land, at a cost of about $500,000, divided into 12 separate tracts. These are designated as state parks. Ninety per cent. of the area of these parks is devoted to game propagation. Most of the large springs in the Ozarks and a large percentage of its clear and rapid streams either originate or flow through state parks.

UNIVERSITY AND EDUCATIONAL NOTES

THE contract has been let for the construction of the Martin Maloney Memorial Laboratory for medical research work at the University of Pennsylvania. It will be erected at a cost of $500,000.

WITH the organization and establishment during the coming year of the Giannini Foundation for Agricultural Economics at Berkeley, another division of research and instruction will be added to the College of Agriculture of the University of California. Another unit of the agricultural building group, to cost approximately $500,000, will be constructed shortly to house the foundation and to provide temporary additional space for other departments of the college. An endowment of approximately a million and a half dollars will support the work of this foundation. Chief divisions of instruction will be in the fields of plant science, animal science, entomology and parasitology, agricultural economics and forestry.

DEAN J. H. SKINNER, of the school of agriculture of Purdue University, Indiana, has been appointed director of the Purdue University Agricultural Experiment Station and of the agricultural extension department of the university, to succeed Dr. G. I. Christie, who has resigned, after twenty-three years of service, to become president of Ontario Agricultural College at Guelph.

PROFESSOR JAMES H. HANCE, head of the department of geology at the Agricultural and Mechanical College at College Station, Texas, has been appointed dean of the Oregon State Agricultural College, to succeed Dr. Charles E. Newton, who recently resigned.

AT the University of Chicago, Drs. Warder C. Allee and Carl R. Moore, zoology; Edwin A. Burtt, philosophy; W. J. G. Land, botany; Harvey B. Lemon, physics, and Frank E. Ross, astronomy, have been promoted to full professorships.

RECENT promotions to full professorships in the University of Illinois include Dr. Edward A. Boyden and Dr. Otto F. Kampmeier, of the department of anatomy of the College of Medicine in Chicago.

DR. ALFRED HUETTNER, assistant professor of zoology at Columbia University, has been appointed associate professor of biology in the Washington Square College of New York University.

DR. ROBERT DONALDSON has been appointed to the Sir William Dunn chair of pathology at Guy's Hospital Medical School, London. Dr. Donaldson is the author of "Practical Morbid Histology" and other publications.

DR. A. M. DRENNAN, professor of pathology in Otago University, Dunedin, has been appointed professor of pathology in Queen's University, Belfast, Ireland.

DR. JOHANNES LINDWORSKY, professor of psychology at the University at Cologne, has been called to Prague.

DISCUSSION

HELODERMA SUSPECTUM, AUTOMOBILE TOURISTS AND ANIMAL DISTRIBUTION

IN a note in SCIENCE, Mr. P. F. English[1] records two instances of the finding of large lizards at considerable distances from their known native habitats. One of these occurrences is that of *Heloderma suspectum*, the Gila monster, concerning which the author remarks that "any attempt to explain how this lizard found its way to Wheelock [Texas], some four or five hundred miles from its native haunts, would be mere guesswork." Concerning the other, an *Iguana tuberculata* from Central America taken in Texas, admittedly a still more difficult occurrence to explain, he says, "How such a reptile could find its way from its tropical and arboreal habitat in the jungles to the almost treeless plains of Childress, Texas, is an interesting speculation."

The present writer heartily agrees to the interesting character of the speculation induced, but believes that an explanation for the first, if not the second instance, may be offered which will be much better than "mere guesswork." Incidentally a new, or if not new, little considered, factor in animal distribution may be given point.

During the course of a dozen years in my present location I have received from interested and curious persons many specimens of the peculiar or unique animals of the southwest; and there have passed through my hands, mainly from these sources, probably nearly one hundred Gila monsters. During that

[1] English, P. F., "Notes on *Heloderma suspectum* and *Iguana tuberculata*," SCIENCE, Vol. LXVI, No. 1697, p. 37.

period of time, though my work has taken me afield frequently, I have in person come across barely a half dozen of these conspicuous and not very swift lizards. This indicates, first, the extent to which people gather up specimens of animal life that excite their curiosity, and transport them in a spirit of helpfulness, curiosity or cupidity. (I have been asked to pay ten dollars for a very ordinary Gila monster, and been solemnly assured that they were worth one hundred dollars.) Secondly, the modern auto tourist is likely to tire of and release his "specimen" unless he can dispose of it to advantage. I have been the recipient of two *Helodermas,* each of which had been carried for some time by auto touring parties, and for distances of not less than two hundred miles. Further, such a specimen is frequently carried tethered somewhere on the outside of the car by an insecure noose about its neck or leg. Tourists in this region often express a desire to take a "Gila" "back home," anywhere from five hundred to fifteen hundred miles from here—and no doubt many of them attempt to do so. A certain dealer in live animals sells surprising numbers of them for this very purpose.

The finding of the specimen in Texas is no surprise to me. It seems much more certain than "guess work" to assume that such an animal, or any interesting animal of readily transportable size, found even hundreds of miles from its native home, has been carried most of the distance by rail or auto, especially the latter. The *Heloderma* mentioned might easily have wandered from the nearest main highway, even though the distance be considerable, for this lizard is tenacious of life, and that locality would not, I believe, be a particularly unfavorable environment for it.

The principles involved in the foregoing statements have many and various illustrations, as every inspector at a horticultural inspection station on a main auto highway in the southwest can testify. The auto tourist carries everything interesting from where he finds it to some other place; anything from a "horned toad" to an entire cotton plant, leaves, bolls, boll weevils and all. The *Iguana tuberculata* record is, to be sure, somewhat less likely to be the result of transfer by auto, but not unlikely to have come up by train. I have now a live *Iguana sp.* which recently arrived in Tucson in a bunch of bananas by rail from the west coast of Mexico. A few years ago I was the recipient of a live five and one-half foot *Boa imperator,* picked up by an autoist just beyond the border town of Nogales, Sonora. This, I should judge, came up from Central America nearly to the United States by train, thence it certainly came another seventy miles by auto. Mr. Roy McCain, of Tucson, relates that, while hunting a few miles northwest of Pantana, a station about thirty miles east of Tucson, in the foothills of the Rincon Mountains, he met a large lizard which he killed with a stick. This measured three feet in length and must have been an *Iguana sp.,* though unfortunately it was not saved. This was in October, 1927.

I have now alive in my laboratory an opossum, carried into this new (and probably unfavorable) environment from Arkansas. Its captor chanced to tire of it just at this point, but might equally well have elected to turn it loose in some favorable looking spot in the state—or in California. It is known that opossums have previously been released in this region. Arizona (likewise California), has a cordon of horticultural inspectors stationed at strategic points for intercepting and inspecting autos coming into the state. The findings of these inspectors, plus the other instances cited, have served to emphasize for us here the possibilities of auto traffic as a factor in animal distribution in a manner which, perhaps, has not come forcibly to the attention of biologists in many other states. The cotton plant incident is a fact from the experiences of the inspectors.

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THE HALL EFFECT IN SINGLE METAL CRYSTALS

IN spite of the very great amount of work which has been done on the Hall effect the fact that we have not yet a satisfactory explanation of this and its allied phenomena justifies further work.

As a result of observations which I made some years ago on tellurium, I came to feel that the crystal structure of metals must play a much more important part in the Hall effect than had been recognized. In fact, I expressed doubt as to whether there would be any Hall effect as we find it in metals unless that metal is crystalline. Since then, thin films of bismuth have been obtained in the amorphous state and no Hall effect was found. It appeared, however, as soon as the film, by suitable heat treatment, became crystalline.

Not much work has been done on single metal crystals and yet it seems that this should be a particularly promising line of attack. Some time ago, Van Everdingen and others showed that the Hall effect is different in different directions in a large crystal of bismuth. Two years ago I studied the Hall effect in single copper crystals, the crystal being in the form of a pencil about six millimeters in diameter and ten centimeters long, and the effect appeared to be independent of the direction.

More recently, I have made measurements on a number of specimens of silicon steel, the alloy of 3.8

per cent. silicon commonly used in transformers. By suitable heat treatment Mr. Ruder, of the Research Laboratory of the General Electric Company, had brought these specimens into a monocrystalline condition, the orientation of the cubic lattice being different in the different samples. The Hall effect, measured up to field intensities of 25,000 gauss, was about fifteen times as large as for pure iron and appeared to be independent of the direction of orientation of the crystal.

In his work on a single bismuth crystal, Van Everdingen found that the Hall effect in any direction was given by the relation $E = a \cos^2 \theta + b \sin^2 \theta$, where a and b are the Hall effects, parallel to and at right angles to the principal axes of the crystal. In the case of a cubic crystal one would expect that a and b would be equal; in which event, according to Van Everdingen, the Hall effect should be the same in any direction. Our measurements on copper and on silicon steel confirm this and it would appear, therefore, that further investigation of the effect of crystal structure should be on metals with other than the cubic lattice structure.

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A NOTE ON REPUTED ANCIENT ARTIFACTS FROM FREDERICK, OKLAHOMA

IN SCIENCE for February 10, 1928 (p. 160), I voiced several objections to the view that certain artifacts found at Frederick, Oklahoma, were of early Pleistocene age. I suggested that the objects called metates by Figgins and Cook might not be artifacts. This is an error. Having since examined them at the Colorado Museum of Natural History I am certain that two or more are unequivocably metates. This does not militate against my other objections.

During a recent visit to the site Dr. Frank Melton and I found chips, the refuse of blade flaking, on the surface of the gravel deposit, but none occurring in the bed itself. This is conformable with my suggestion that the artifacts taken from the bed are surface material recently included. Dr. Hay will recognize that if the surface chips are of Aftonian age, a possibility he suggests,[1] they should occur in the gravel bed.

This gravel deposit caps a narrow ridge. It is markedly gullied by erosion along its margins, especially in the vicinity of the finds. My suggestion was that the artifacts may have lain in such a gully. Dr. Hay misunderstands that I envisage a deep hollow on top of the ridge, which, as he observes, is incredible, and to which I add, unnecessary.

[1] SCIENCE, April 27, 442.

The replies of Dr. Hay and Mr. Cook[2] do not impel me to revise my opinion that the case for antiquity is unproven.

LESLIE SPIER

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AN EXPLANATION

IT has been brought to my attention that in the paper entitled "The Common Ground of the Chemist and Biologist" in the issue of SCIENCE for July 13 there is a statement referring to tuberculin that has been given a significance which was not intended. This sentence at the bottom of the first column on page 23 reads as follows:

> It is a dirty compound of many substances concentrated from a boiled beef broth medium and bacilli and yet it is used as the basis for destroying millions of dollars worth of cattle annually and for the diagnosis of human tuberculosis.

This was an unfortunate use of the word "dirty" and has resulted in a wholly erroneous impression. The word "complex" would have been more accurate and better from every point of view.

The tuberculin long employed has unquestionably proven of great value and while we hope that a product of more definite composition will prove of even greater utility, this awaits further investigation.

WILLIAM CHARLES WHITE

U. S. PUBLIC HEALTH SERVICE

A MAGNETIC STORM

A SEVERE magnetic storm was recorded at the magnetic observatory of the U. S. Coast and Geodetic Survey at Cheltenham, Maryland, on July 7–8, 1928. It was characterized by its sudden onset, great intensity and comparatively short duration. It began at about 6:30 P. M. eastern standard time, July 7, and continued until about six o'clock the next morning. The period of greatest intensity occurred in the early morning hours. About half an hour after midnight the magnets of the horizontal intensity and vertical intensity variometers went beyond the limits of the record and the motion of the declination magnet was frequently too rapid to make a record on the photographic paper. The extreme range of the fluctuations, as nearly as could be determined, amounted to 4° in declination, more than 1,270 gammas in horizontal intensity and more than 640 gammas in vertical intensity. During this storm there was a wonderful display of aurora borealis and telegraph and telephone lines were seriously disturbed.

GEORGE HARTNELL

U. S. COAST AND GEODETIC SURVEY

[2] SCIENCE, April 6, 371.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A RAPID METHOD FOR DETERMINING COLORIMETRICALLY THE PH OF SMALL AMOUNTS OF SOLUTIONS

THE chief difficulty encountered in determining colorimetrically the H-ion concentration of small amounts of fluid is that of obtaining uniform small samples. Spotting plates with depressions and small glass dishes are not convenient for frequent use. The pipette described here provides a means of rapidly obtaining uniform samples for color comparisons following a method similar to that proposed by Felton.[1]

A short length of non-soluble glass capillary tubing of about 0.75 mm bore and 2.5 mm outside diameter is fitted into a combined rubber bulb and stopper for each standard solution and indicator to be used. The cross-section area of the capillary is quite constant and each pipette will deliver a drop of almost exactly the same size. At the same time the pipette, Fig. 1,

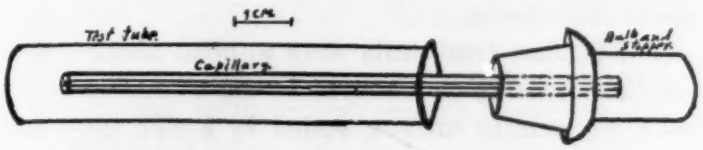

Fig. 1.

serves as a stopper for the test tube or bottle containing the solutions to be used.

The combined drops of standard and indicator will stand up like colored glass beads if a very thin layer of pure white vaseline be put on the spotting plate. This will not affect the pH of the mixture if a good grade of vaseline be used. The comparisons of the colors may be made to ± 0.1 pH. Kymograph paper may be used in place of a spotting plate for classes if it be lightly coated with vaseline.

Standard solutions, of known pH, kept in 12 x 100 mm Pyrex glass test-tubes may be kept for about a year if protected from the light in a box such as is used for filing 4 x 6 inch cards. The tubes may be kept upright by placing them in holes bored in a board placed on the bottom of the filing box. This amount of solution is sufficient for about two hundred determinations. The H-ion concentration may be tested within a very few minutes. A set of standards made in this way requires only a small investment for material as well as being particularly convenient for tests in which the color method may be used. This method has been used by the writer for research[2] and class purposes with complete success for over three years.

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[1] Felton, L. D., *Jour. Biol. Chem.*, 1921, 46: 299.
[2] Richards, O. W., *Jour. Gen. Physiol.*, 1928, 11: 525.

AUTOMATIC, ELECTRICALLY CONTROLLED, TEMPERATURE AND HUMIDITY FRAMES FOR PLANT PROPAGATION

CONSIDERABLE interest is now manifest in high temperature and humidity propagating frames, particularly in connection with the rooting from cuttings of subtropical and tropical fruits. The subject has been of special importance in the multiplication of the lychee, China's most popular fruit.[1]

Accurate control of both temperature and humidity is a simple matter, but no effective device for this purpose in connection with propagating frames has thus far come to the writer's notice. In connection with recent work upon the lychee on the ranch of Wm. A. Spinks, Duarte, Calif., a frame has been devised in which both the temperature and the relative humidity of the air are controlled, the latter by the separate regulation of the temperature of water in a water-pan. The frame consists of a tightly constructed propagating-case with hinged sash. At the bottom is a shallow copper pan for water, the sides of which in this case fit snugly into the frame. Over the pan there is a false bottom of wire mesh upon which the pots or boxes of cuttings are placed. The air is heated by means of electric globes, and the water by means of an electric heater. Air and water temperatures are controlled by separate thermostats. For lychee propagation it is desired to secure an air temperature of 85° F. and humidity of 80. For this the water must be held at 78° F. When outside temperatures do not rise much above 70° F., control of both temperature and humidity is readily obtained. When they rise above this point the water in the pan must be cooled by injecting a stream of cool water through the pan or by spraying the outer surface of the pan with cool water.

Under high temperatures, such as those experienced in the tropics and subtropics, the installation of a refrigeration unit will prove necessary. An experimental frigid frame, using this principle, is now being devised for temperature and humidity control in plant propagation. It is believed that a frame of this kind will not only prove of service for rooting cuttings, but also in hot countries for starting winter vegetables and flowers during the summer months, these to be transplanted in the fall months of lowered temperatures. Details for the construction of the frame will be published from Lingnan University, Canton, China, by Dr. H. S. Frank, who is advising regarding the physical side of the development. The writer will be glad for information concerning similar efforts in this direction.

G. WEIDMAN GROFF
BERKELEY, CALIF.
May 18, 1928

[1] Galloway, B. T., *Journal of Heredity*, 13: 201–206, 1922.

SPECIAL ARTICLES

MUTATIONS IN BARLEY INDUCED BY X-RAYS AND RADIUM

AT the Nashville meeting of the American Association last December I reported the occurrence of mutations in barley following X-ray treatment.[1] The experiments, which were independent of and coincident with those of Muller,[2] though by no means so comprehensive and thorough, confirm Muller's discovery of the power of X-rays to induce mutation and show its application to plants. They show also that mutations may be induced similarly by radium treatment.

The treatments were applied to germinating seeds, and the induced mutations recorded were in all cases somatic mutations affecting the progeny of only part of the plant. The experiments were set up in this way in order to exclude the possibility that new characters appearing after treatment might be ascribable to some irregular segregation from hybrid ancestry. The barley plant produces several tillers from axillary buds, each tiller terminating in an inflorescence of about thirty self-fertilizing flowers. In the dormant embryo the first three or four leaves are already differentiated, and the cells from which the tillers will be developed are separated. A mutation occurring in one of these cells, therefore, will affect only one tiller, and, whether dominant or recessive, will segregate in the progeny of only one head.[3] Its absence in the progeny of other heads of the same plant shows that the genetic change occurred during the development of the plant treated, for any ancestral character, however inherited, would affect all head progenies of the individual similarly.

The X-ray treatments were applied intermittently in twelve equal exposures at one-hour intervals, while the seeds were germinating under optimum conditions. A 30 m.a. "radiator-type" self-rectifying Coolidge tube was used, operated at a tube current of 5 m. a. Treatments were made at seventy-eight kilovolts (peak), two and three quarter minutes per exposure, and at fifty-four kilovolts, five and one half minutes per exposure, in an attempt to apply approximately equal quantities of radiation differing somewhat in quality. At each voltage a "heavy" and a "light" treatment were applied simultaneously, at target distances of 22.7 and 45.4 cm, respectively. The radiation passed through two samples of seed at shorter distances, and the filtering effect of the wet blotters and seeds must be considered in computing dosage. Ionization measurements made later showed that this reduced the intensity of the radiation at the higher voltage by about 52 per cent., and of that at the lower voltage by about 65 per cent. The relative ionizing intensity of the heavy and light treatments at the higher voltage and the heavy and light treatments at the lower voltage was in the ratio 100: 21: 50: 9. The so-called heavy doses were not heavy enough to reduce viability appreciably, but a dose of approximately three times this intensity, with the higher voltage, was found to be partially lethal. I am indebted to the department of physics of this university for the use of the X-ray equipment, and particularly to Mr. R. T. Dufford, of that department, for much advice and assistance and for the construction of an ionization chamber of the Duane type,[4] with which the dosage measurements above were made.

The radium treatments were applied under similar conditions, using as a source 50 mg of radium in the form of radium sulfate, sealed in a thin glass tube within a tube of silver 1 mm thick. Dr. Dudley A. Robnett, of Columbia University, generously lent his personal supply of radium for the treatments. The seeds, germinating in stacked watch glasses, were exposed continuously for twelve or twenty-four hours at distances ranging from one and a half to eleven cm. The maximum dose (applied to seeds in the dishes immediately above and below that containing the radium tube) was well below the limit of tolerance.

The mutations previously reported were three seedling chlorophyll defects, "white," "virescent," and "yellowing." White seedlings are colorless from emergence, and die in two to three weeks. Virescent seedlings are colorless at emergence, but gradually develop a pale green color. With care they may be kept alive for a long period, but they grow very slowly. Both white and virescent seedling types have previously been reported as Mendelian characters in barley. Yellowing seedlings are green and apparently normal at emergence, but about a week later they pass through intermediate shades to full yellow and die soon after.

These three mutations were found among seventy-seven head progenies, representing twenty-six X-rayed plants. Each mutant type made up one fourth to one eighth of a single head progeny from a plant of which other head progenies were entirely normal. If the segregation is due to a mutation affecting one head

[1] Experiments on the effects of X-rays on crossing over and chromosome distribution, reported in the same communication, have been published separately. (*Proc.* Nat. Acad. Sci., 14: 69–75, 1928.)

[2] SCIENCE, 66: 84–87, 1927.

[3] Under favorable conditions tillers are sometimes developed from the axillary buds of earlier tillers. In such cases more than one head may be affected by the same mutation.

[4] *Am. Jour. Roent. and Rad. Therapy,* 10: 935–943, 1923.

or part of a head, some of the normal plants from this head should segregate the same mutant character in the following generation, while none of the plants from the unaffected heads should do so. This expectation was realized in the next generation, in which eight of the sixteen normal plants tested from the head which segregated white seedlings were found to be heterozygous for white, seven of the twelve plants tested from the head which segregated virescent were heterozygous for virescent, and three of the seven plants tested from the head which segregated yellowing were heterozygous for yellowing. In each case about fifteen plants from unaffected heads of the mutating plant were tested, and all gave entirely normal progeny.

The remaining progenies have since been planted and seedling segregations noted. The total frequency of mutations resulting in definite and conspicuous seedling characters is shown below:

	Total number of head progenies examined	Number segregating mutant seedling characters
X-ray treated:		
Higher voltage		
Heavy dose	210	6
Light dose	259	1
Lower voltage:		
Heavy dose	494	6
Light dose	280	1
Total X-rayed	1,243	14
Radium treated:		
Total for all doses	1,039	3
Untreated	1,341	0

The majority of the mutations listed were white seedlings. Tests of genetic identity have not yet been made, but it is probable that many of these represent mutations at different loci. At least three genetically distinct white seedlings have previously been reported in barley, and in maize, in which genetic analysis has been more intensive, dozens of genes for white seedling are known.

The mutations following radium treatment included two whites and one virescent. Since the radiation passed through 1 mm of silver and at least 5 mm of glass before reaching the seeds, it consisted largely of gamma rays. The fact that mutation frequency was lower in the radium series than in the X-ray series does not imply that radium is less effective than X-rays in inducing mutation, since the intensity of the radium treatment was probably much lower. All three mutations occurred in the plants receiving the heavier doses.

A preliminary trial was made also of the possibility of increasing the effectiveness of X-ray treatment by impregnating the seeds with salts of heavy elements. Since in general X-ray absorption increases approximately in proportion to the fourth power of the atomic number of the absorbing element, it may be increased materially by the presence of even a small amount of some heavy element within the cell. The seeds were soaked for seven hours in M/5 solutions of the salts listed below. The X-ray treatment, which began fifteen hours later, was similar to that described above as heavy dosage at the higher voltage, but the intensity was about 40 per cent. higher. The frequency of mutation for distinct seedling characters is shown below:

Treatment		Number of head progenies	Number of mutations
Radiation	Chemical		
X-rayed	$Ba(NO_3)_2$	136	9
X-rayed	$Pb(NO_3)_2$	133	9
X-rayed	$UO_2(NO_3)_2$	194	11
X-rayed	none	72	2
Not X-rayed	$UO_2(NO_3)_2$	53	0
Not X-rayed	none	76	0

Although the numbers are too small to justify a final conclusion, the results suggest that the chemical treatments increased the effectiveness of irradiation. The mutations included, in addition to types already noted, the following seedling characters: "yellow," "pale yellow," "yellow-green," "banded" (transverse white bands), "striped" (two distinct patterns) and "tapering" (a morphological peculiarity). Several possible mutations for less conspicuous seedling characters are omitted from the summary pending further investigation.

In all, forty-eight mutations causing distinct seedling characters have been found following irradiation. These include almost all the seedling characters of barley previously reported and several not previously described. No mutations have yet been found in untreated plants, of which about fifteen hundred head progenies have been examined.

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THE NUCLEAR CONDITIONS IN THE SPERMATOCYTES OF DROSOPHILA MELANOGASTER

IT is a surprising fact that very little has been known until recently concerning the nuclear condi-

tions in the spermatocytes primary and secondary of *Drosophila melanogaster*. In conversation with a number of investigators in this field the opinion has been reached that those who have investigated the cytology of this interesting species consider that no known reagent is capable of preserving the meiotic divisions in the male gonad. This is all the more surprising because the ordinary somatic divisions as well as those occurring in the spermatogonia and oogonia can be so easily and beautifully preserved. The situation becomes still more anomalous when one reflects that a spermatogonium may occur a small fraction of a millimeter removed from a primary spermatocyte. It is opposed to all cytological experience that the somatic or sporophytic mitoses should be preserved without difficulty, whilst the reduction divisions can not be fixed at all. We are now acquainted with the cytology of a huge number of plant hybrids and in these cases the preservation of the reduction divisions presents no greater difficulty than does that of the ordinary body cells of the plant.

Apparently the difficulties of our genetical colleagues concerning the cytological phenomena in the reduction divisions occurring in the sperm-mother cells of *D. melanogaster* are the result of their general unfamiliarity with the reduction divisions in the case of hybrids. The botanist who has any cytological knowledge at all is quite familiar with these and may even have seen them in his own preparations. Obviously, the abnormalities which appear in the male meiotic mitoses of *D. melanogaster* are not in general the result of defective fixation. A consideration of the situation in a plant hybrid will make this point clear. If we take two good species of plants, such, for example, as *Rumex crispus* and *R. obtusifolius*, we find that both their sporophytic and meiotic divisions are entirely normal. If, on the other hand, we examine the not uncommon hybrid between these two species, we discover at once that extreme abnormalities in the reduction divisions (although not in the sporophytic divisions) are present when exactly the same technical procedure is pursued as in the case of the parent species. These abnormalities in the meiotic mitoses of hybrid plants have been so widely studied that it is possible to formulate them. They are variations in numbers of chromosomes, the occurrence of different combinations of chromosomes such as bivalents and univalents, and, above all, the lagging of these chromosomes whether univalent or bivalent on the spindle, in division.

It is an interesting and apparently highly significant fact that the reduction divisions in the male organs of *D. melanogaster* present an exact parallel to those found in the corresponding divisions of known hybrids or extremely variable species among plants. The opinion is now widely held on the botanical side that extreme variability in plants, especially when accompanied by the meiotic phenomena of known hybrids, is certain evidence of heterozygous or hybrid origin. These accompanying phenomena are of very wide occurrence in large genera of plants from the Algae to the Angiosperms.

Our genetical colleagues should, apparently, as a consequence of this general situation, be less pessimistic about the possibility of fixing the reduction divisions of *D. melanogaster*. We hear a good deal at the present time about the necessity of exploiting the frontiers between the various sciences. In biology apparently the frontiers between the different subdivisions of the science are to too large a degree *terra incognita*. The zoologists know too little of what is going on over the botanical boundary and also the botanist is often lamentably ignorant of the conditions across the fence of his zoological neighbor. One of the most deplorable limitations of the present time is the lack of cooperation between experimental and comparative students of biology. Obviously, the comparative anatomist and the cytologist have much to learn by utilizing the results obtained by the experimental worker. Similarly, the experimental worker may equally avoid the danger of progressing in a vicious circle by keeping his eyes fixed on the comparative horizon.

As the result of the examination of a very large additional amount of material of *D. melanogaster* originating both from Professor Morgan's laboratory and from numerous sources in the wild, the conclusion is reached that in all cases the male meiotic phenomena are highly abnormal and resemble in important respects those observed in known or experimentally produced plant and animal hybrids. That the abnormalities in question are not the result of fixation seems clear not only because they resemble those found in hybrid plants and animals but because they present themselves in substantially the same aspects with different methods of preservation. It is accordingly once more asserted that *D. melanogaster* in contrast to some other species of the genus, both as a result of its extreme variability and its meiotic phenomena, is to be regarded as of heterozygous or hybrid origin. This conclusion will naturally make necessary, if it be substantiated by the works of other investigators, a profound modification of the inferences in regard to the origin of species which have been derived from the genetical study of *D. melanogaster*.

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